Effect of Wheat Harvest on Regional Clmate: Experiments with the Coupled MM5-ISOLSM Model

William Riley, Heather S. Cooley[1], and Margaret S. Torn
[1]University of California, Berkeley
Contact: William Riley, 510/486-5036, wjriley@lbl.gov

RESEARCH OBJECTIVES

Surface energy and water fluxes are tightly coupled with CO_2 exchanges between the ecosystem and atmosphere. Other surface-to-atmosphere trace-gas exchanges of interest in climate change research are also strongly impacted by surface energy exchanges. Further, land-use change has considerable impact on the surface energy balance and therefore the exchanges of these trace gases. To investigate these issues at the regional scale, we have coupled the meteorological model MM5 with ISOLSM (Riley et al., 2002; 2003), a land-surface model that, in addition to simulating the surface energy balance, predicts gaseous and aqueous fluxes of climatically relevant species within the soil and between the ecosystem and atmosphere.

APPROACH

Here we describe a modeling investigation of the impact of the winter wheat harvest on surface fluxes, air temperatures, and regional climate in the Southern Great Plains Atmospheric Radiation Measurement–Cloud and Radiation Testbed (ARM–CART) region (Cooley et al., 2003). We chose to study the winter wheat harvest because wheat accounts for about 20% of the ARM-CART land area, and the fields are typically harvested within a two-week period. Two harvest dates, bracketing the interannual range in the region, were simulated and compared: “early harvest” on June 4 and “late harvest” on July 5.

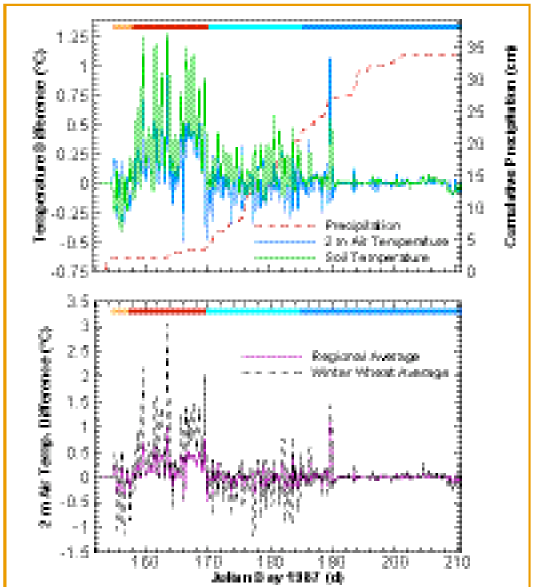

Figure 1. (a) Differences (relative to the late harvest scenario) in cumulative precipitation and in 2 m air and soil temperatures averaged over the ARM-CART region show four distinct time periods (solid bars at top). (b) Differences in 2 m air temperature in the harvested area and averaged over the entire region. Air temperatures were substantially higher in the harvested area.

ACCOMPLISHMENTS

Differences in latent and sensible heat fluxes, 2 m air and soil temperatures, and precipitation varied over the two-month simulation. During the first three days after harvest, midday latent heat fluxes increased substantially, and much of the near-surface soil moisture was lost via evaporation. Over about the next two weeks, midday latent heat fluxes decreased, as transpiration was eliminated and evaporation was sharply reduced in the harvested area. The concurrent increase in sensible heat fluxes resulted in midday air-temperature increases of about 1°C. After the second harvest, air temperature and soil moisture and temperature levels rapidly converged between the two scenarios, indicating that the system has relatively little memory of the early harvest.

Changes within the harvested areas are substantially larger than the regionally averaged results (Figure 1); further, there are some edge effects. For example, latent heat fluxes increased and sensible heat fluxes decreased in areas adjacent to the harvest because of the drier air being advected from the harvested region.

SIGNIFICANCE OF FINDINGS

Simulations of the winter wheat harvest in the ARM-CART region indicate that coherent harvesting substantially impacts regionally averaged and local surface conditions and climate. These findings highlight the importance of land use change on climate; in the near future we will use the model to study interactions between land use changes and the changing global climate.

RELATED PUBLICATIONS

Cooley, H.S., W.J. Riley, and M.S. Torn, Effect of harvest on regional climate and soil moisture and temperature, in Chapman Conference on Ecosystem Interactions with Land Use Change, Santa Fe, NM, 2003.

Riley, W.J., C.J. Still, M.S. Torn, and J.A. Berry, A mechanistic model of $H_2{}^{18}O$ and $C^{18}OO$ fluxes between ecosystems and the atmosphere: Model description and sensitivity analyses, Global Biogeochemical Cycles, 16, 1095-1109, 2002.

Riley, W.J., C.S. Still, B.R. Helliker, M. Ribas-Carbo, S. Verma, and J.A. Berry, Measured and modeled $\delta^{18}O$ in CO_2 and H_2O above a tallgrass prairie, Global Change Biology, 2003 (in press).

ACKNOWLEDGMENTS

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